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BEAR LAKE, FREEBORN COUNTY, MINNESOTA

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center
Minnesota Pollution Control Agency
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January 1975

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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ON
BEAR LAKE
FREEBORN COUNTY
MINNESOTA
EPA REGION V
WORKING PAPER No. 110

WITH THE COOPERATION OF THE
MINNESOTA POLLUTION CONTROL AGENCY
AND THE
MINNESOTA NATIONAL GUARD

JANUARY, 1975

II

CONTENTS

	Page
Foreword	ii
List of Minnesota Study Lakes	iv, v
Lake and Drainage Area Map	vi
Sections	
I. Introduction	1
II. Conclusions	1
III. Lake Morphometry	2
IV. Precipitation	2
V. Lake Water Quality Summary	3
VI. Appendix	7

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS*

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

* The lake discussed in this report was included in the National Eutrophication Survey as a water body of interest to the Minnesota Pollution Control Agency. Tributaries and nutrient sources were not sampled, and this report relates only to the data obtained from lake sampling.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

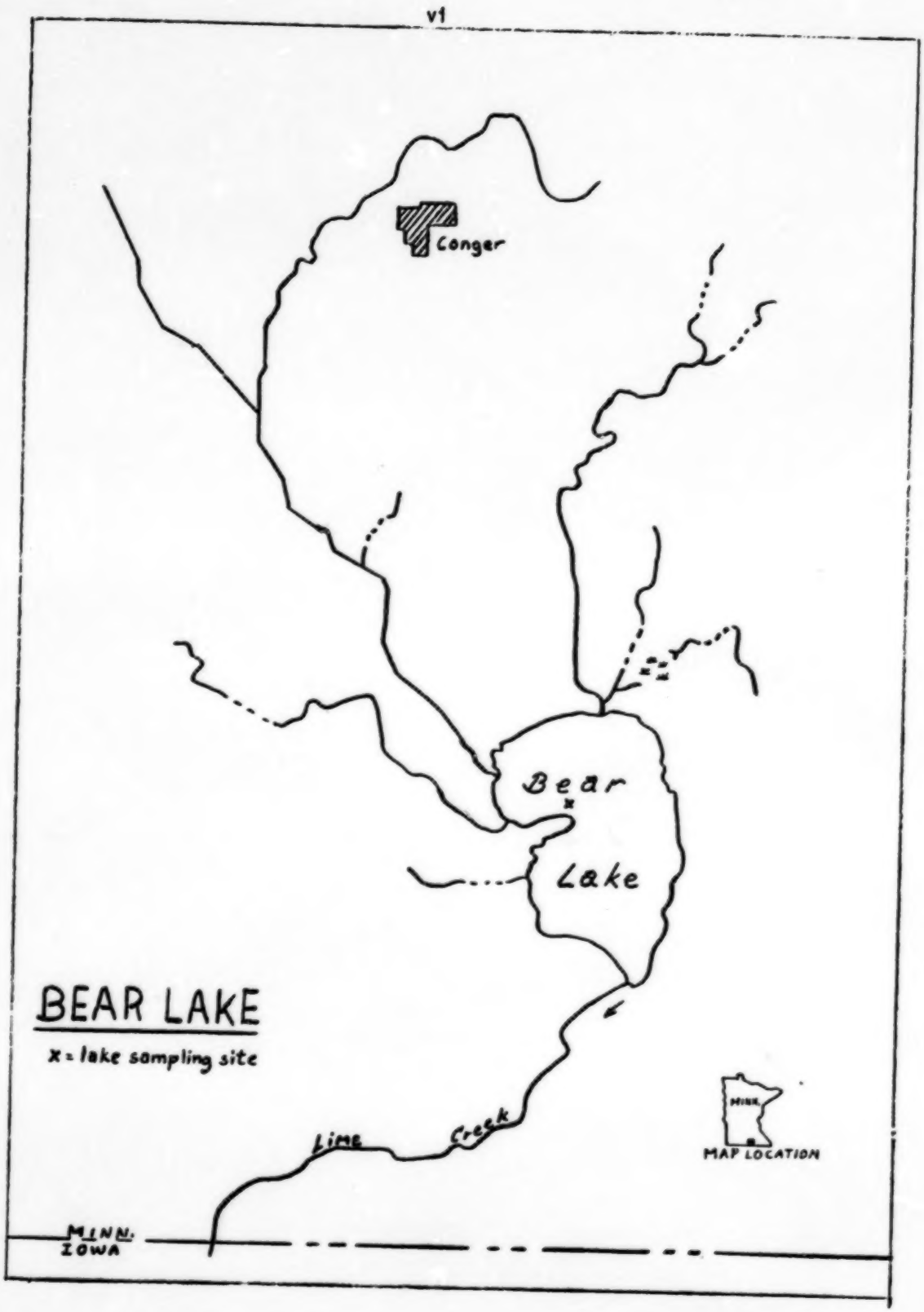
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


Conger
Bear
Lake
BEAR LAKE
x = lake sampling site
Lime Creek
MINN.
IOWA
MAP LOCATION

BEAR LAKE

STORET NO. 2706

I. INTRODUCTION

Bear Lake was included in the National Eutrophication Survey as a water body of interest to the Minnesota Pollution Control Agency. Tributaries and nutrient sources were not sampled, and this report relates only to the data obtained from lake sampling.

II. CONCLUSIONS

A. Trophic Condition:

Survey data show that Bear Lake is eutrophic. Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, 36 had less mean total phosphorus, 32 had less mean dissolved phosphorus, and 56 had less mean inorganic nitrogen. Of the 80 Minnesota lakes sampled, 61 had less mean chlorophyll a, and 73 had greater Secchi disc transparency.

Survey limnologists observed heavy blue-green algal blooms in July and late August and noted the presence of abundant rooted aquatic vegetation.

B. Rate-Limiting Nutrient:

A significant loss of nutrients occurred in the assay sample from the time of collection to the beginning of the assay, and the results are not indicative of conditions in the lake at the time of sampling.

The lake data indicate nitrogen limitation in early July and late August (N/P ratios were 9/1) but phosphorus limitation in late October (N/P = 55/1).

III. LAKE MORPHOMETRY*

A. Surface Area: 1,374 acres.

B. Mean Depth: 2.3 feet.

C. Maximum Depth: 4.0 feet.

D. Volume: 3,160 acre feet.

IV. PRECIPITATION

A. Year of Sampling: 42.4 inches.

B. Mean Annual: 28.7 inches.

* DNR lake survey map (1958); mean depth by random-dot method.

V. LAKE WATER QUALITY SUMMARY

Bear Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, a surface sample for physical and chemical parameters was collected from one station on the lake (see map, page vi). During each visit, a depth-integrated (near bottom to surface) sample was collected for phytoplankton identification and enumeration; and a similar sample was taken for chlorophyll a analysis. During the last visit, a five-gallon depth-integrated sample was collected for algal assays.

The results obtained are presented in full in the Appendix, and the data for the fall sampling period, when the lake was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to the Appendix.

A. Physical and chemical characteristics:

FALL VALUES

(10/29/72)

Parameter	Surface Sample Only
Temperature (Cent.)	7.5
Dissolved oxygen (mg/l)	12.1
Conductivity (μmhos)	500
pH (units)	8.2
Alkalinity (mg/l)	186
Total P (mg/l)	0.066
Dissolved P (mg/l)	0.030
NO_2 + NO_3 (mg/l)	1.480
Ammonia (mg/l)	0.170

ALL VALUES

	Minimum	Mean	Median	Maximum
Secchi disc (inches)	23	28	30	30

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
07/01/72	1. Merismopedia	52,963
	2. Microcystis	32,963
	3. Synedra	6,667
	4. Anabaena	4,074
	5. Flagellates	2,563
	Other genera	11,511
	Total	110,741
08/30/72	1. Microcystis	97,614
	2. Lyngbya	31,815
	3. Merismopedia	25,307
	4. Fragilaria	17,354
	5. Aphanocapsa	11,569
	Other genera	34,707
	Total	218,366
10/29/72	1. Microcystis	12,932
	2. Dinobryon	3,233
	3. Flagellates	2,782
	4. Fragilaria	2,707
	5. Lyngbya	2,105
	Other genera	10,376
	Total	34,135

2. Chlorophyll *a* -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
07/01/72	01	62.5
08/30/72	01	92.6
10/29/72	01	28.6

VI. Appendix

STORET RETRIEVAL DATE 74/10/30

270601
43 33 06.0 093 30 06.0
BEAR LAKE
27 MINNESOTA

11EPALES
3

2111202
0002 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/01	09	10 0000		6.6	12	420	8.40	120	0.210	0.210	0.331	0.048
72/08/30	15	10 0000	22.0	9.4	9	373	8.60	121	0.230	0.260	0.176	0.052
72/10/29	13	20 0000	7.5	12.1	12	500	8.20	186	1.480	0.170	0.066	0.030

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/01	09	10 0000	62.5J
72/08/30	15	10 0000	92.6J
72/10/29	13	20 0000	28.6J

J VALUE KNOWN TO BE IN ERROR